REMOVAL OF ARSENIC FROM SYNTHETIC WASTE WATER USING

ADSORPTION PROCESS

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ABSTRACT

Environmental pollution particularly from heavy metals and minerals in the waste water is the most serious problem in India. Arsenic is viewed as being synonymous with toxicity. Dangerous arsenic concentration in natural water is now a world-wide problem. Existing overviews of arsenic removal technology that has traditionally been used: Adsorption. Adsorption process being very simple, economical effective and versatile has become the most preferred methods for removal of toxic contaminants from wastewater. In this project we use the iron acetate coated activated alumina (IACAA) and activated alumina (AA) as a adsorbents. The adsorption potential of IACAA for removal of arsenic [As (III)] as arsenite by batch sorption technique gives more effective results in comparision to AA. Percentage adsorption on IACAA and AA were determined as a function of contact time and adsorption dose. IACAA was characterized by EDAX (energy dispersive x-rays analysis) and SEM (scanning electron microscope). The impact of the amount of impregnated iron acetate in activated alumina on arsenic adsorption capacities was investigated in this study. In this study we also described the preparation of iron acetate and coating of iron acetate on activated alumina.

KEYWORDS: Arsenic, Iron Acetate, Activated Alumina, Adsorption

Original Article

INTRODUCTION

Environmental pollution particularly from heavy metals and minerals in the waste water is the most serious problem in India. Due to extensive anthropogenic activities such as industrial operations particularly mining, agricultural processes and disposal of industrial waste materials; their concentration increased to dangerous levels.

Water pollution generally occurs due to the contamination of water bodies (e.g. Lakes, riverse, oceans, aquifers, and groundwater). Inorganic species of heavy metals represent a potential threat to environment, human and animal health due their carcinogenic and other effects. Long term drinking water exposure causes skin, lung, bladder and kidney cancer as well as pigmentation changes, skin thickening (Hyperkeratosis), neurological disorders, muscular weakness, and loss of appetite. Heavy metals in industrial effluent include arsenic, lead and cadmium. So far, a number of efficient methods have been reviewed for the removal of heavy metals such as chemical precipitation, ion exchange, reverse osmosis, electrodialysis, ultrafiltration, nanofiltration, coagulation, flocculation, floatation, adsorption, etc. Adsorption process being very simple, economical, effective and versatile has become the most preferred methods for removal of toxic contaminants from wastewater. Now a day, the adsorption process is getting the best preference over other treatment processes.

Preparation of synthetic waste water: standardized As (V) 1000 ppm solution was used for the preparation of

As(V) solution. Sodium arsenate salt ($Na_2HAsO_4.7H_2O$) was used to preparation of stock solution of arsenate. For preparing 1000 ppm solution, dissolve 2.08 gm of the sodium arsenate salt in small amount of water and raise the extent using distilled water up to 1000 ml.

Kinetic studies were done to study the effect of adsorbent dose, contact time and effect of initial concentration on the impurities removal rate. For kinetic studies, the different amount of the adsorbent dose (0.5, 1.0, 1.5, 2.0, and 2.5 gm/250ml) was used and kept in contact with the standard solution for the same interval of time. A 250 ml volume of 50 ppm of arsenic solution was taken in a beaker. To each beaker different amount of adsorbent was added and kept in contact with the arsenic solution for the fixed interval of time. The pH of the arsenic was maintained at 7.4 by adjusting with HNO_3 and NaOH solution. After finding the optimum adsorbent dose, the effect of contact time was studies. Each 250 ml of solution in the beaker was stirred with fixed amount of adsorbent dose at the different interval of time (30, 60, 90, 120 and 150 minute). After finding the optimum contact time, the effect of initial concentration was studies. The different ppm solution (50, 100, 150, 200 and 250 ppm) was studies, fixed amount of adsorbent dose and optimum contact time. Each 250 ml solution in the beaker was stirred with optimum adsorbent dose and optimum contact time.

The samples were collected into separate bottles and were analysed by using the UV-spectrophotometer. Spectrophotometer was calibrated using standard solution of the heavy impurities that were being analysed. Wavelength of 193.7 nm was used in UV-spectrophotometer for arsenic.

MATERIALS AND METHODS

Preparation of Iron Acetate

Preparation of iron acetate carried out in four steps:

Preparation of Iron Solution

1 gm ferromagnetic powder and 250 ml of 0.5M aqueous oxalic solution were put into a 500 ml three-neck round bottom flask and stirred for one hour (pH of solution is 1). At this time, the temperature of the solution in the flask was controlled by heating mantle and was set to 100^0C. After the stirring is completed, non-soluble components were separated and removed through a filtration to prepare iron solution.

Preparation of Iron Hydroxide

100 ml of the prepared iron solution was put into a three-neck round bottom flask and sodium hydroxide was added thereto so that pH of iron solution is 4. When pH of the solution had reached to 4 by the addition of the sodium hydroxide, the reaction solution was filtered to separate the resultant precipitate from the mother liquor and then the precipitate was dried in a vacuum drier to prepare iron hydroxide.

Preparation of Iron(II) Acetate

1 gm of the prepared iron hydroxide and 10 gm of acetic acid were put into a three-neck round bottom flask and reacted at a temperature of 50^0 C, for 1 hour 45 minutes. Then, iron(II) acetate precipitate at the bottom of the flask was separated from reacted mother liquor by a filtration and recovered iron(II) acetate particles were washed with distilled water until pH of the washed liquid had reached to 7. After the completion of the washing, the iron(II) acetate particles were dried a vacuum oven in nitrogen atmosphere to prepare iron(II) acetate.

Preparation of Iron Acetate Coated Activated Alumina(IACAA) was Carried Out in Two Steps

- In first step, 25 gm of activated alumina was impregnated with 25 ml of 1.5 M iron acetate in a heat resistant dish and the mixture was heated to 110^0C after thorough mixing, until it became dry.

- The same mixture was calcined at 400^0C for 3 hour, cooled to room temperature and washed with distilled water until the washed water became clear.

RESULTS AND DISCUSSIONS

Effect of Adsorbent Dose: In Figure 1, the X-axis represent the different amount of adsorbent dose in gm/250ml and Y-axis represents the % removal of arsenic after treatment with the respective adsorbents at wavelength of 193.7 nm. It showed the maximum removal by using 2.0 gm/250ml of the adsorbent dose. An amount of 2.0 gm/250ml of respective adsorbents could remove 81 % and 60 % for IACAA and AA respectively of arsenic from the solution.
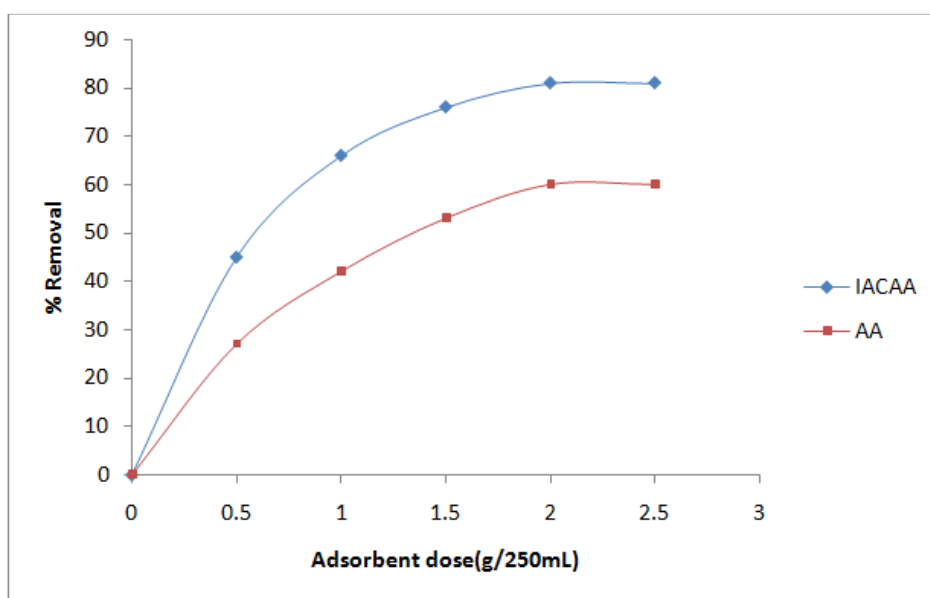
Figure 1: Effect of Adsorbent Dose on As (III) Adsorption at Adsorbent Dose= 2.0g/250mL, Contact Time = 120 min
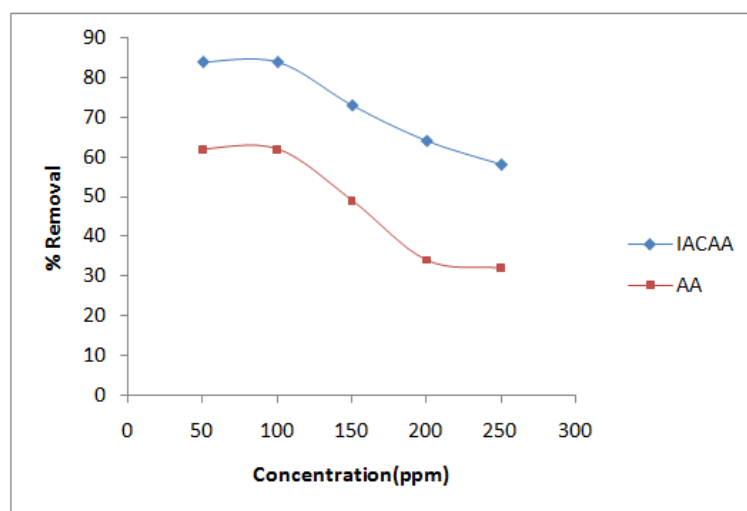
Effect of Contact Time

In Figure 2, the X-axis represent the time in minute and the Y-axis represent the % removal of arsenic after treatment with the respective adsorbents. It is indicated from the above figures that the maximum removal is at 120 minute. An amount of 2.0 gm/250ml of respective adsorbents can remove the 83% and 61 % for IACAA and AA respectively of the arsenic from the solution within the time duration of 120 minutes.
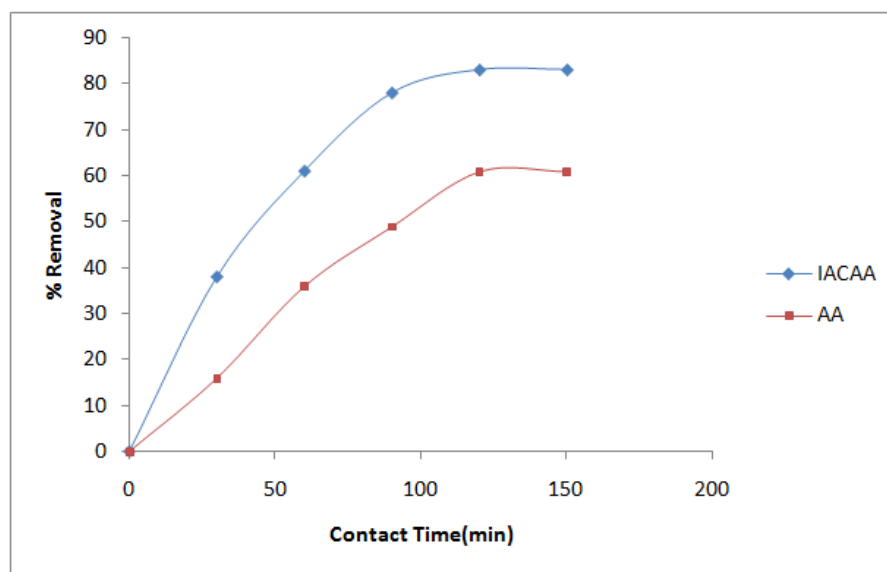
**Figure 2: Effect of Contact Time on As (III) Adsorption at Adsorbent
Dose= 2.0g/250mL, Concentration = 50ppm**

Effect of Initial Concentration

In Figure 3, the X-axis represent the concentration in ppm and the Y-axis represent the % removal of arsenic after treatment with the respective adsorbents. It is indicated from the above figures that the maximum removal is at 50 ppm. An amount of 2.0 gm/250ml of respective adsorbents can remove the 84 % and 62% for IACAA and AA respectively of the arsenic from the solution within the time duration of 120 minutes.

**Figure 3: Effect of Initial Concentration on As(III) Adsorption at
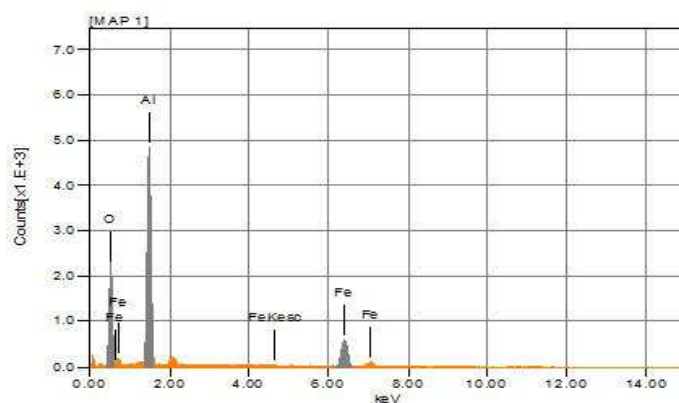Adsorbent Dose= 2.0 g/250ml, Contact Time=120 min.**

Figure 4

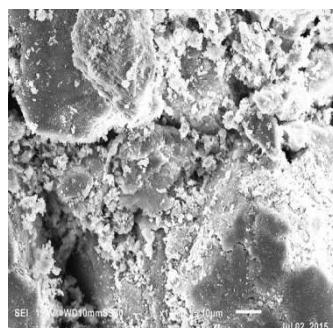**EDAX Pattern of IACAA Sample**

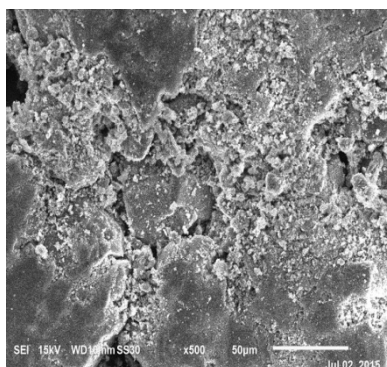**Figure 5**

SEM Images of IACAA Sample

Figure 6

CONCLUSIONS

The overall study reveals that the adsorption of arsenic onto AA and IACAA is found to be dependent on adsorbent dose and contact time. The removal of arsenic containing waste water with IACAA was found and give better result is 83% removed at 2.0 gm/250ml adsorbent dose, continuous stirring for 120 minute of contact time and removal of arsenic containing waste water with activated carbon (AA) was found and give better result is 60% removed at 2.0 gm/250ml adsorbent dose, continuous stirring for 120 minute of contact time.

REFERENCES

1. *Acharyya SK: Arsenic contamination in groundwater affecting major parts of southern West Bengal and parts of western Chhattisgarh: source and mobilization processes. Curr Sci 2002, 82:740–744.*

2. *Singh AK: Chemistry of arsenic in groundwater of Ganges-Brahmaputra river basin. Curr Sci 2006, 91(5):599–609.*

3. *Devi NL, Yadav IC, Shihua QI: Recent studies of arsenic contamination in groundwater of Northeastern India- a review Report and opinion 2009. 1(3):22–32.*

4. *Mandal BK: Arsenic in groundwater in seven districts of West Bengal, India - the biggest arsenic calamity in the world. Curr Sci 1996, 70(2):976–986.*

5. *Smedley PL, Nicolli HB, Macdonald DMJ, Barros AP, Tullion JO: Hydrogeochemistry of arsenic and other inorganic constituents in groundwater from La Pampa, Argentina. Appl Geochem 2002, 17(3):259–284.*

6. *Smedley PL, Kinniburgh DG: In United Nations Synthesis Report on Arsenic in Drinking Water, Chapter 1, Water and Sanitation, Protection of the Human Environment, British Geological Surve. Wallingford, Oxon OX10 8BB, UK; 2005.*

7. *Greenwood NN, Earnshaw A: Chemistry of Elements. Oxford: Pergamon Press; 1984.*

8. *Ferguson JF, Davis J: A review of the arsenic cycle in natural waters. Water Res 1972, 6:1259–1274.*

9. *WHO: International Programme on Chemical Safety. Arsenic, Geneva: Environmental Health Criteria 18; 1981.*

10. *Xu YH, Nakajima T, Ohki A: Adsorption and removal of arsenic from drinking water by aluminum-loaded Shirasu-zeolite. J Hazard Mater 2002, 92:275–287.11McNeill S, Edward M: Predicting arsenic removal during metal hydroxide precipitation. J AWWA 1997, 89:75–82.*

11. *Singh TS, Pant KK: Equilibrium, kinetics and thermodynamic studies for adsorption of As (III) on activated alumina. Sep Purif Technol 2004, 36:139–147.*

12. *Zang FS, Itoch H: Iron oxide-loaded slag for arsenic removal from aqueous system. Chemosphere 2005, 60:319–325.*

13. *Kundu S, Gupta AK: As (III) removal from aqueous medium in fixed bed using iron oxide–coated cement (IOCC): Experimental and modelling studies. J Chem Eng 2007, 129:123–131.*

14. *Genc H, Tjell JC, McConchie D, Schuiling O: Adsorption of arsenic from water using neutralized red mud. J Colloid Interface Sci 2003, 264:327–334.*